The Use of Titanium as a Corrosion Barrier in Discrete Power MOSFET Device Automotive Reliability Testing

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Corrosion of metal in integrated circuits has historically been a serious problem for semiconductor devices encapsulated in plastic mold compounds [1]. Plastic packages are popular in the commercial microelectronic packaging industry because of their relatively low cost [2]. However, because of their high permeability, plastic packages offer less resistance to moisture ingress than hermetic packages. Plastic device package materials are not good barriers to the external environment and usually contain high levels of corroding materials. In extreme cases of corrosion, the metal lines can be etched away thereby leaving an open circuit condition.

Improvements in passivation technology have largely eliminated interconnect corrosion as a reliability problem, but bonding pad corrosion remains an issue. In discrete Power MOSFET (Metal Oxide Semiconductor Field Effect Transistor) devices, corrosion of unpassivated bondpads is a much more serious issue since active components are typically placed beneath them. Recent technology trends have pushed manufacturers to put active device components beneath the bondpads in order to gain more active area without increasing overall die size. Furthermore, leading manufacturers have even made the wire bonding area as big as the entire die to allow multiple wire bonds, which gains even more performance. These designs do not leave much area for a passivation layer to protect the metalization. Nitride passivation is typically used only on the edges of the bonding areas leaving the metalization extremely vulnerable to corrosion.

Power MOSFET devices are typically sold to automobile manufacturers that place these parts in harsh environments and requires extremely low failure rates. Automotive manufacturers always require reliability testing specifically designed to test the corrosion susceptibility of microelectronic parts.

In this study we investigate an alternate Power MOSFET bondpad metalization scheme to eliminate corrosion, especially during automotive reliability testing that is specifically designed to identify corrosion susceptibility. In the alternative metal scheme, titanium is used as the corrosion barrier. In figure 1, the devices processed without the titanium overcoat showed significant fallout for Rdson after 96 hours of automotive reliability testing. Rdson is an electrical performance parameter all manufacturers strive to improve. It is defined as the conduction loss of the device when it is turned on. This parameter is important since many end applications utilize the device as a low loss switch [3] and depend on conduction losses in the switch to be minimized. In addition, we will investigate other issues such as the effect of the new metal on overall device processing and device electrical performance. While some changes were necessary to implement the titanium into the standard device fabrication process, it did not degrading device electrical performance, fab yield, cost basis or packaging capability.

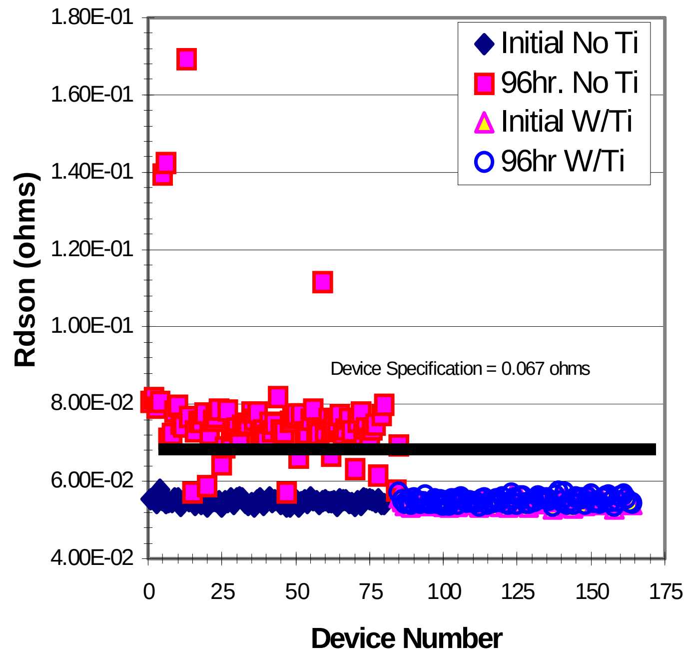

Fig.1 A comparison of initial to final (after a 96 hr automotive reliability test) Rdson measurements for the standard and titanium overcoat devices.

References

[1] VanOverloop, "An Investigation of Corrosion on Integrated Circuits via Pressure-Temperature-Humidity - Bias Stressing," IEEE Transactions on Reliability, 1990, vol. 39. No.1 p.30.

[2] M. Pecht, "A Model for Moisture Induced Corrosion Failures in Microelectronic Packages," IEEE Transactions on Components, Hybrids, and Manufacturing Technology, Vol. 13, No. 2, p. 383, June 1990.

[3] General Electric Power Transistor Data Book, 1985.